light-keepers, and shepherds, none keep the solitary, anxious watch of the night nurse or the watching mother. There has never been anything quite like it since the world began, and no woman ever goes through it who does not all the rest of her life carry a shadowy remote corner in her mind and heart into which no one else may enter, nor can she ever look out into the night at a late hour and alone that she does not think of those solitary watchers in the great hospitals, in quiet city houses, in cottages and tenements in remote villages and on lonely farms, and with a throb of sympathy pray for their guidance and safety.

(To be continued.)

RELATION OF BACTERIA TO DISEASE

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Ever since the discovery of bacteria, over two centuries ago, many theories as to their connection, if there be any, with the diseases of man have been offered and rejected. Even as late as 1821 such a relation was considered as absurd. After that it was generally admitted that the bacteria and certain diseases were found together, which of them being cause and which effect not having been positively decided to the satisfaction of anyone.

In discussing this question it is evident that there are three factors to be considered, the micro-organism itself, the animal infected, and the resulting disease which is the sum total of the result of the characteristics of the other two factors.

In diseases caused by micro-organisms one characteristic is possessed by all, that is the ability to get from one individual to another. No matter what specific infectious disease it is, it is always possible to carry or transmit it from one individual to another, this property of transmissibility being characteristic of infectious diseases. The question is, then, what is it in the disease which can be transmitted and which will at the same time answer the other requirements of multiplication and change in the tissues?

In the disease itself two factors are involved—first, "infection," and, secondly, "intoxication." Infection is the entrance into the tissues of the body of a specific micro-organism which is capable of producing changes in those tissues. Man can contract certain diseases which the lower animals cannot, such as typhoid. Even the races of man are dif-

ferentiated, the negro being considered immune from yellow fever and the Japanese from scarlet fever. The lower animals have certain diseases to which man is not susceptible. Should the bacteria of these diseases enter the tissues of man they would have no effect. But if man be subject to the disease and the specific organism of that disease enter the tissue certain chemical substances are produced by these bacteria, often at the expense of the tissue itself. These chemical substances are formed by the bacteria in much the same way that the chemical substances are formed from the foods taken into the living body. These chemical compounds, in their turn, produce changes and symptoms in the individual infected, the changes and symptoms being termed "intoxication." This intoxication cannot be carried from one individual to another any more than one person could take a dose of medicine, say a sedative, and another person get the effects of the dose.

Therefore the intoxication is not the cause of the disease because it does not stand the test of transmissibility, which is the essential characteristic of the infectious diseases.

Now test the chemical substances which are elaborated by the bacteria. It is known that no chemical substance has the power of multiplication. The effect observed would be directly proportionate to the chemical substance introduced. That is, if we introduce a certain amount of chemical compound we would get just that amount of intoxication. This is not true, however, as we know that a small amount injected yields a proportionally large intoxication.

Micro-organisms, the other factor in infectious diseases, do possess the power of multiplication, as even a single cell produces symptoms out of all proportion to the amount injected. They also possess the power of transmissibility, and are capable of producing intoxication through the action of their chemical products. They answer, therefore, all requirements.

The thing to do, then, is to find the specific organism and to prove that in a certain given disease one particular bacterium produces that one specific disease. Even then we cannot say that this bacterium is the only one, but we are justified in believing that it is the cause in this case.

In solving this problem Koch, who has given to the world so many new methods for bacteriological investigations, formulated four rules or laws by which he believed we could positively demonstrate the causal relation between a micro-organism and a given disease: 1. The organism must be present in all cases of that disease. 2. The organism must be isolated and obtained as an absolutely pure culture. 3. The pure culture of an organism when introduced into susceptible animals must produce the disease. 4. In the disease thus produced the organism must be found distributed the same as in the natural disease.

To these may be added a fifth: the chemical products of the organism must produce the characteristic symptoms and effects of that disease.

The constant presence of an organism is proved by making hanging-drop examinations of the fluids and exudates of the diseased body and by staining sections of the tissues and organs. Sometimes this is impossible. In this case other animals are injected with the organism. If the animal dies and the examination of its bodily tissue shows the presence of the same bacillus which was injected, we are justified in identifying it with the injected bacilli, as we can only get life from life. This occurrence, however, may only be coincident. A pure culture must be obtained.

This is done by transferring the organism thus found to a plate media. When developed, transfer one colony to another culture media, either gelatine, bouillon, or agar. We may be sure this is a pure culture.

In most cases of diseases the organism has been found and a pure culture obtained. In leprosy, however, a pure culture has not been obtained, and in scarlet fever and measles the presence of an organism has not been definitely shown.

Having secured and isolated the micro-organism, the second factor in the question may be considered—*i. e.,* the infection of an animal. The susceptibility of the animal is taken note of and the number of bacteria injected proportioned to the size of the animal. Lastly, the avenue of inoculation is carefully selected.

The most common methods of inoculation are cutaneous application, subcutaneous injection, intravenous injection, injection into special regions such as the anterior chamber of the eye, into the substance of the lung, or the lymphatics. More rarely intra-cranial injection, as in rabies infection, along the respiratory tract and of the alimentary canal. These include all the ways in which a man may contract a disease.

The cutaneous application is illustrated by boils and felons. The bacteria in this case are rubbed in with fat or vaselin.

The subcutaneous method is the common hypodermic method. The tetanus infection is an example of this. In artificial inoculation mice and rats are inoculated over the root of the tail, guinea-pigs and rabbits on the side.

The intravenous method is most important, as it is the direct introduction of the bacteria into the circulation. This is done with a syringe or injection apparatus. A rabbit is used as much as possible for this, as the vein on the posterior margin of the ear answers all purposes very well. If a large amount of toxin is injected, the jugular vein is used. This method is followed in inoculating horses in diphtheria. The results are rapid.

The anterior chamber of the eye is used in inoculating with tubercle

bacillus. A slit is made or a needle introduced at the edge of the iris and the fluid injected into the anterior chamber directly.

At times the bacterium is injected directly into the pleural cavity or into the peritoneal cavity. Infection of the alimentary canal is brought about by swallowing the bacteria with the food. A new-born animal is preferable for this, as there are so many bacteria in the adult alimentary tract. The respiratory tract is infected by inhalation.

The infected animal must now be observed for the symptoms of the disease. The principal points to be watched are the weight, temperature, and respiration. A steady, though slight, decrease in weight shows chronic wasting disease and *vice versa*. Temperature per rectum is important, as temperature is a good indicator of the action of bacterial poison on the animal tissue. These symptoms must agree with phenomena already observed in this disease.

The most important results are obtained from post-mortem methods. The fluids and exudates from the diseased portions of the body are transferred to culture-media in plates as soon as possible after death. From these isolated colonies agar, bouillon, gelatine, and potato cultures are made. Hanging-drop examinations are made. If the organism thus examined shows the same characteristics in every respect as the organism injected, we can state safely that this specific organism is the cause of this disease in this instance.

Every step of the Koch method has been followed in the anthrax bacillus. A further step in the subject would be to isolate the chemical substances elaborated by the bacteria and prove that they can produce the intoxication present in the disease. When these chemical substances which are produced by the bacteria are in sufficient numbers to form lesions in the tissues death results. If, however, the tissues have sufficient power to withstand the action of the chemical substance, the individual is said to be immune. The immunity to disease may be artificially produced.

THE New Orleans *Medical and Surgical Journal,* commenting editorially on the educational advancement in medicine, attributes the moral and intellectual progress to the influence of State registration and the honest manner in which the laws have been administered. "Even the layman sees the advance, and, although he is daily invited to a survey of a host of flagrant and pretentious notices of cure-alls in the daily press, anyone may read that in their bold and brazen claims these parasites must eventually die a natural death."